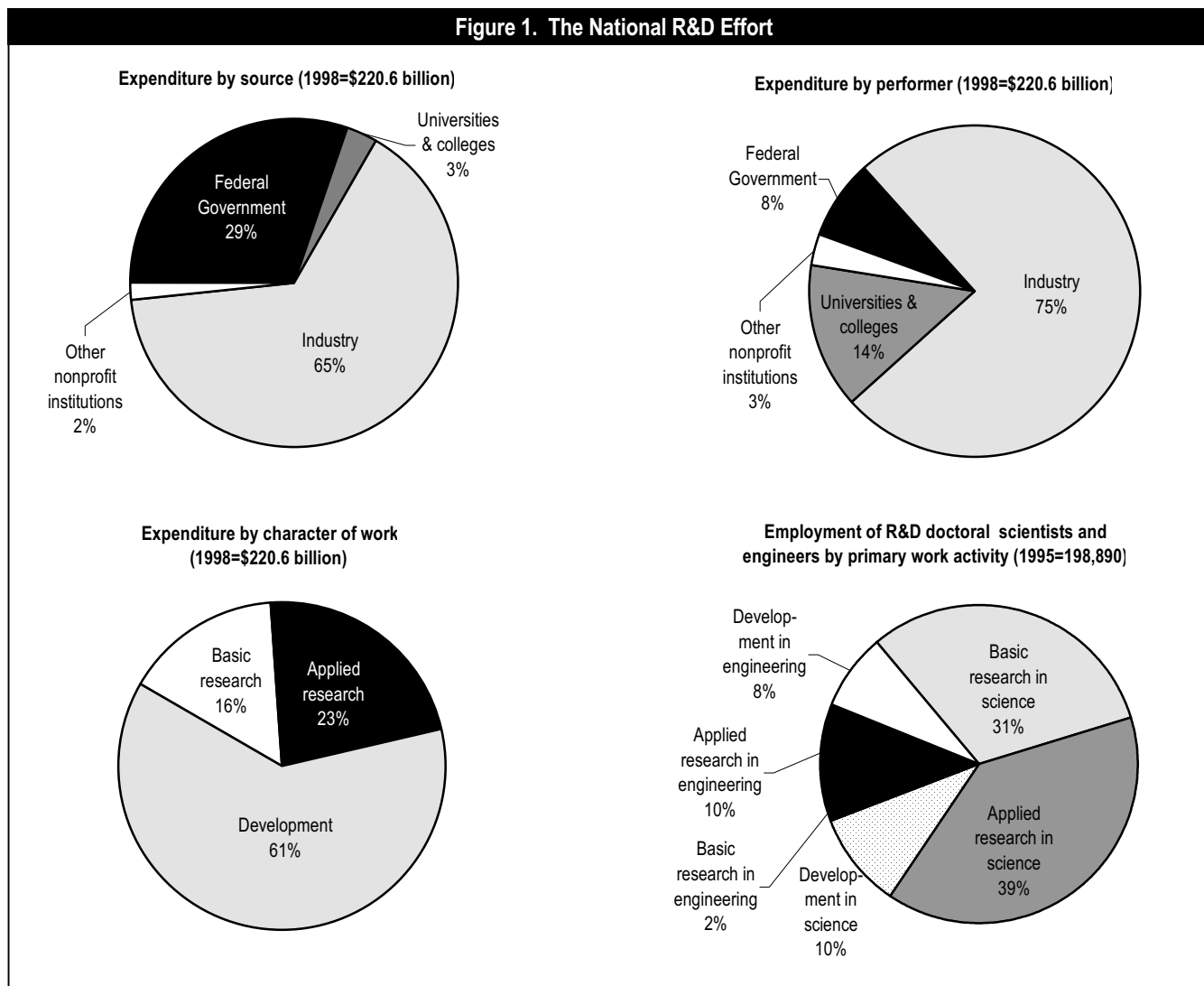# HIGHLIGHTS

TOTAL R&D EXPENDITURES

- By current projections, total annual research and development (R&D) expenditures in the United States will be $220.6 billion in 1998, of which 65 percent will be provided by industry (figure 1). This level of R&D expenditure represents a 5.3-percent increase, after adjusting for inflation, over the $205.6 billion estimated for 1997. In turn, the 1997 estimate represents a 2.8-percent increase over 1996, and the 1996 level a 4.7-percent increase over 1995, after adjusting for inflation in each case.

- The entire economy of the United States, as measured by gross domestic product (GDP) is estimated to reach $8,456 billion in 1998. Adjusted for inflation, GDP increased an estimated 2.7 percent in 1998, after a 3.8-percent increase in 1997, and a 2.8-percent increase in 1996. Consequently, R&D as a share of GDP will reach 2.61 percent in 1998, up from 2.54 percent in 1997, and 2.57 percent in 1996. This 1998 share is the highest since 1992's 2.64 percent, and reflects a continuation of a general upturn that began in 1994 after a three-year decline from 1991–94.

Figure 1. The National R&D Effort

Expenditure by source (1998=$220.6 billion)

- Universities & colleges 3%
- Federal Government 29%
- Industry 65%
- Other nonprofit institutions 2%

Expenditure by performer (1998=$220.6 billion)

- Federal Government 8%
- Universities & colleges 14%
- Other nonprofit institutions 3%
- Industry 75%

Expenditure by character of work (1998=$220.6 billion)

- Basic research 16%
- Applied research 23%
- Development 61%

Employment of R&D doctoral scientists and engineers by primary work activity (1995=198,890)

- Development in engineering 8%
- Applied research in engineering 10%
- Basic research in engineering 2%
- Development in science 10%
- Basic research in science 31%
- Applied research in science 39%

NOTES: Details may not add to 100 percent because of rounding. R&D funds for federally funded R&D centers are included in their affiliated sectors. For employment of R&D doctoral scientists and engineers, development in science and development in engineering include "design."

SOURCE: National Science Foundation/Division of Science Resource Studies; tables B-1A, B-2A, B-2B, B-3A and B-28.

- Growth in total U.S. R&D expenditures was relatively slow in 1985–95, but is now accelerating. In the past, annual R&D growth had been much higher—e.g., from 1975–85 it averaged 5.6 percent in real terms. That rate then slowed to 1.6 percent in 1985–95. However, annual real R&D growth in 1995–98 is expected to average 4.3 percent. Almost all of the recent growth in national R&D expenditures is the result of a resurgence of industrial R&D.

- Despite this recent increase, the R&D share is still below levels reached in the early 1990s (2.64 percent in 1992). The historic high since 1957 for the Nation's R&D/GDP ratio was reached in 1964 at 2.87 percent; the low was 2.12 percent in 1978.

INDUSTRY PARTICIPATION

- Since 1980, industry has provided the largest share of financial support for R&D, projected to reach $143.7 billion in 1998, or 65.1 percent of the total. This funding represents a 7.7-percent increase in real terms over the preliminary 1997 level. Of these funds, nearly all ($140.8 billion) will be devoted to R&D performed by industry itself, with the remainder directed toward academic R&D ($1.8 billion) and R&D performed by other nonprofit organizations ($1.0 billion).

- Industry—including industry-administered federally funded research and development centers (FFRDCs)—is expected to perform 75.1 percent of the Nation's total R&D in 1998. The projected $165.7 billion in R&D performance by industry represents an 8.5-percent increase in real terms over the preliminary 1997 level. Of this industrial R&D performance in 1998, 85.0 percent will be supported by industry's own funds; Federal funding will account for the remaining 15.0 percent. The Federal share of industry's performance total has fallen considerably from its all-time high of 32 percent in 1987.

FEDERAL PARTICIPATION

- Federal R&D support in 1998 is expected to be $66.6 billion, a 0.8-percent increase in real terms over 1997. The Federal share of support for the Nation's R&D first fell below 50 percent in 1978,

and it remained between 45 and 50 percent until 1988. It then fell steadily, dropping from 42.6 percent in 1988 to a current all-time low of 30.2 percent projected for 1998.

- The Federal Government is expected to perform $16.9 billion of R&D in 1998, a real increase of 0.2 percent from 1997. Federal agencies are estimated to account for 7.7 percent of national R&D performance in 1998, reflecting, again, a continual decline in the Federal performance share that began in the mid-1970s.

PARTICIPATION OF UNIVERSITIES, NONPROFIT ORGANIZATIONS, AND STATE GOVERNMENTS

- Other R&D funds, provided by universities and colleges, state and local governments, and other nonprofit institutions, in combination, are expected to reach $10.3 billion in 1998, reflecting a 3.4-percent real increase over their 1997 level.

- Universities and colleges, excluding academically administered FFRDCs, are expected to account for 11.6 percent ($25.7 billion) of national R&D performance in 1998; this is a moderate real increase (3.1 percent) over 1997.

R&D SEPARATED INTO BASIC RESEARCH, APPLIED RESEARCH, AND DEVELOPMENT

- Of the projected $220.6 billion spent on R&D in 1998, $34.4 billion (or 15.6 percent) is expected to be for basic research, $49.8 billion (22.6 percent) for applied research, and $136.4 billion (61.8 percent) for development. In comparison with 1997, R&D performance in 1998 reflects a 2.4-percent real increase in basic research, a 6.2-percent real increase in applied research, and a 5.8-percent real increase in development.

- The amount of basic research conducted as a proportion of total R&D varies enormously by sector. From 1970–98, basic research was between 62 and 67 percent of all university and college R&D (including university and college-administered FFRDCs). For industry

R&D (excluding industry-administered FFRDCs) it has ranged between only 3 and 6 percent, and for Federal intramural R&D it has ranged between 13 and 17 percent. This maximum of 17 percent for basic research as a percentage of Federal R&D is expected for 1998, reflecting an upward trend that has been occurring since 1988.

- Industry and industry-administered FFRDCs, combined, are expected to account for 25.0 percent ($8.6 billion) of the Nation's basic research performance in 1998. Universities and colleges are expected to account for 51.1 percent ($17.6 billion), and their FFRDCs for another 7.8 percent ($2.7 billion). The remaining basic research performance will be carried out by the Federal Government, comprising 8.3 percent ($2.9 billion) of the total, and by other nonprofit organizations and their affiliated FFRDCs—7.8 percent ($2.7 billion). While Federal Government performance of all R&D is expected to rise only 0.2 percent in real terms, Federal performance of basic research is expected to rise 4.2 percent.

R&D PERFORMANCE BY STATE

- R&D is substantially concentrated in a small number of states. In 1995, California had the highest level of R&D expenditures—over $36 billion—representing approximately one-fifth of the $177 billion U.S. total. The six states with the highest levels of R&D expenditures—California, Michigan, New York, Massachusetts, New Jersey, and Texas (in decreasing order of magnitude)—accounted for approximately one-half of the entire national effort.

- The 10 states with the highest R&D intensity (ratio of R&D to Gross State Product) in 1995 were, in descending order, New Mexico (8.1 percent), the District of Columbia, Michigan, Massachusetts, Maryland, Delaware, California, Connecticut, Rhode Island, and Washington (the latter with an intensity of 3.5 percent)

U.S./INTERNATIONAL COMPARISONS

- Due to the size of its economy, the United States spends more on R&D than any other country, though it does not spend as high a proportion of its economy on R&D as some other countries. In 1996, the most recent year for which comparable international data are available, the U.S. spent 2.57 percent of its GDP on R&D, compared to 2.77 percent spent by Japan in 1995 (the latest year's data available for that country), 2.32 by France, 2.28 by Germany, 1.94 by the United Kingdom, 1.66 by Canada, and 1.03 by Italy.

- Nondefense R&D as a percent of GDP was 2.11 for the United States in 1996, which was lower than for Germany (2.20), and Japan (2.73 in 1995), but higher than for France (2.04 in 1995), the United Kingdom (1.71), Canada (1.63), and Italy (0.98 in 1995).

R&D SCIENTISTS AND ENGINEERS

- The estimated number of scientists and engineers employed in 1995 on R&D activities in the United States is approximately 987,700. This figure reflects a 1.3-percent average annual increase from the 1993 level of 962,700. It reflects only a 2.1-percent annual increase over the 1985 figure of 801,900, the first year for which revised national tabulations are available.

- In 1996, industry employed approximately 859,300 full-time equivalent (FTE) R&D scientists and engineers (S&Es). The industrial sector with the most R&D S&Es was transportation equipment, with 18.5 percent of the FTE total, mostly involving R&D on aircraft and missiles. Electrical equipment was the second-largest employer of R&D S&Es, with 15.2 percent, mostly involving R&D on electronic components such as computer chips. Chemical and allied products accounted for another 10.7 percent, and machinery, including office computers, accounted for another 10.2 percent. The next largest R&D S&E employment sector was in services, rather than manufacturing—computer and data processing services accounted for 9.4 percent of all industrial R&D S&Es.

- In 1995, approximately 484,780 doctoral scientists and engineers were employed in the United States; 41.0 percent reported R&D as their primary work activity; teaching as a primary activity accounted for 22.1 percent; management/sales/administration, 16.4 percent; computer applications, 4.4 percent; and other professional services and activities, 16.2 percent.

WHY STATISTICS ON R&D EXPENDITURES ARE COLLECTED AND ANALYZED

Economic growth is widely viewed as a key factor that influences the well-being of individuals and societies. In broad terms, it is attributable to two processes: growth in economic resources—natural resources, labor, and physical capital—and improvements in quality and productivity—producing more and/or better products from the same resources. The first of these, while an important source of growth, is often limited by basic physical constraints. For example, a nation may experience economic growth through an expanded labor force, but economic output per person may remain unchanged. More natural resources may be exploited, but often at the expense of limiting their availability for future use. In contrast, the accumulation of physical capital, i.e., structures and equipment, is more commonly welcomed as a reflection of economic progress. Such accumulation, though, also drains additional resources, either directly through additional consumption of fuel and materials, or indirectly through depreciation and its associated replacement costs.[1]

The second causal factor of economic growth—improvements in quality and productivity—need not involve the kinds of trade-offs associated with the growth of economic resources. Through improvements in human capital, physical capital, and organizational operations, advances in science and engineering can offer more and/or better products without consumption of additional resources. Such advances, or technological changes, may not always be beneficial, as adverse consequences sometimes lead to the realization that not all new technologies are worthwhile. Nevertheless, knowledge is usually cumulative, and as societies learn from their mistakes, people and nations might continue to benefit from scientific and engineering accomplishments.

It follows that economic growth, especially in the long run, is highly dependent on the R&D activities of scientists and engineers. However, the precise relationship between R&D and improvements in quality and productivity (such as the time lag between R&D and its economic effects) has been extremely difficult for economists to identify and measure, and that relationship varies greatly by the types of products and services developed.[2]

Moreover, like expenditures on anything, expenditures on R&D may tell little about the ultimate quality or value of what is received from the money being spent. This is especially the case when one is examining individual projects, where any assessment of the true value of an endeavor is confounded by its interaction with other R&D projects. In the aggregate, this interaction among industrial sectors, "or interindustry technology flows" has, itself, become a topic of research and analysis.[3]

As an example of the complexity of R&D analysis, even if a project is deemed a complete failure, its failure might provide researchers with the knowledge that the particular path undertaken had been wrong, thereby helping to steer future R&D endeavors in the right direction. In addition, philosophical and cultural issues could arise in any assessment of a project. For instance, basic research enhances fundamental knowledge, which in turn enhances applied knowledge. Nevertheless, whether, or to what extent, fundamental knowledge is a desired end in itself would be determined, in part, by societal values, rather than economic analysis alone.

Yet, despite the uncertainties about the meaning and value of information on R&D expenditures, such information is collected extensively by the United States

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[1] Economists familiar with this topic might criticize this perspective as simplistic, because productivity increases may be embodied in the quantity of measured capital. (See, for example, Griliches, Z., "Hedonic Price Indexes and the Measurement of Capital and Productivity: Some Historical Reflections," in *Fifty Years of Economic Measurement: The Jubilee of the Conference on Research in Income and Wealth*. E. Berndt and J. Triplett, eds., University of Chicago Press, Chicago, 1990; and Payson, S. "The Difficulty of Measuring Capital, Revisited," *Technological Forecasting and Social Change, Vol.* 56, No. 2, October 1997.)

[2] For recent analyses of the relationship between R&D and economic growth, see, for example: Griliches, Zvi, "Productivity, R&D, and the Data Constraint." *American Economic Review* Vol. 84: 1–23, 1994; Nordhaus, William D. (1994) "Do Real Output and Real Wage Measures Capture Reality? The History of Lighting Suggests Not." Cowles Foundation Discussion Paper No. 1078, September, 1994; Payson, S., "Quality Improvement Versus Cost Reduction: A Broader Perspective on Evolutionary Economic Change," *Technology Analysis & Strategic Management,* Vol. 10, No. 1, 69–88, 1998; and Rosenberg, N., and R. Nelson. "American Universities and Technical Advance in Industry." *Research Policy* Vol. 23: 323–348, 1994.

[3] See, for example, Schnabl, H., "The Subsystem—MFA: A Qualitative Method for Analyzing National Innovation Systems—The Case of Germany," *Economic Systems Research*, Vol. 7, No. 4, 1995.

and many other nations, and it is disseminated and studied worldwide by analysts in a wide variety of fields. One reason for this broad interest is that *aggregate* R&D expenditure data is a measure of the level of economic purchasing power that has been devoted to R&D projects as opposed to alternative economic activities. More precisely, industrial (private-sector) funding of R&D, which represents most of R&D expenditure in the United States, may be interpreted as an economic measure of how important R&D is to U.S. companies, which could have easily devoted those funds to any number of other purposes. Likewise, government support for R&D reflects government and society's commitment to scientific and engineering advancement, which is an objective that, of course, competes for dollars against other functions served by discretionary government funding. The same basic notion holds as well for the other sectors that fund R&D—universities and colleges, and other nonprofit organizations.

In effect, in broader terms R&D expenditures measure the *perceived* economic importance of R&D *relative* to all other economic activities. Because institutions invest in R&D without knowing the outcome (if they did know the outcome, then it would not be R&D), the amount they devote will be based on their perception, rather than their knowledge, of R&D's value. As already argued, that value is relative because it competes with other forms of investment.

Such information about R&D's perceived relative value is extremely useful for economic decisionmaking. For example, if R&D in a particular field of study increases, this may reflect an increase in demand for scientists and engineers to study and work in that field. An increase in R&D in a particular industrial sector could be among the first signs that the sector is about to expand with new lines of products or services. Of course, R&D data alone would not be enough to accurately analyze the future growth of a field of study or an industrial sector, but it may well be an important input into any such analysis.

In conclusion, the R&D data presented in this report provide important information for economic and social decision making, and may even provide clues into our future as a society. We provide these data for this very reason—to encourage and facilitate useful analyses of the nation's economic and social conditions. As mentioned above, we are now soliciting your feedback on the details of how our data have already been used successfully in published studies. As we acquire this kind of information, we will tabulate and summarize it in future reports, in addition to using it in our continual efforts to improve our data.